Designing A Triple-Extrusion Bioprinter: A Cost-Effective and Precise Approach

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Objective: This study aims to develop a cost-effective triple-extrusion bioprinter to address the high demand for organ transplants, which current bioprinting solutions cannot meet due to their limited bioink capacity and high costs. Our goal is to design a bioprinter capable of printing complex organs using multiple bioinks, thereby improving the feasibility and precision of bioprinting technologies.

Methods: A literature review on existing single and multi-ink bioprinting technologies was conducted to develop insight into the conversion of a 3D printer to a triple-extrusion bioprinter while retaining high XYZ precision. Key modifications included designing a custom x-axis carriage to securely hold three Replistruders, configuring PRUSA slicer software for extruder control, and implementing an alignment grid for consistent prints. The Longer LK5 Pro 3D Printer was determined as an adequate printer frame to accommodate the larger size needed for three Replistruders. Additionally, detailed steps were taken to ensure minimal movement jerk for FRESH (Freeform Reversible Embedding of Suspended Hydrogels) printing, a type of extrusion-based bioprinting in which bioinks are printed into suspended hydrogels that support the desired model during the process.

Results: The triple-extrusion bioprinter conversion was successfully developed with a total cost of $995.60, significantly lower than commercial bioprinters. The designed custom x-axis carriage implemented a full-size slot system between the two main components for increased stability and reduced wear and tear. A converted bioprinter using this protocol would demonstrate the capability to print with three bioinks, highlighting its potential for creating more complex and viable organ structures.

Conclusion: The designed triple-extrusion bioprinter provides a cost-effective and precise solution for printing complex organs. Ongoing research and refinement are necessary to improve consistency and alignment, with future directions focusing on developing an automated alignment system for high-performance multi-material 3D bioprinting.

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